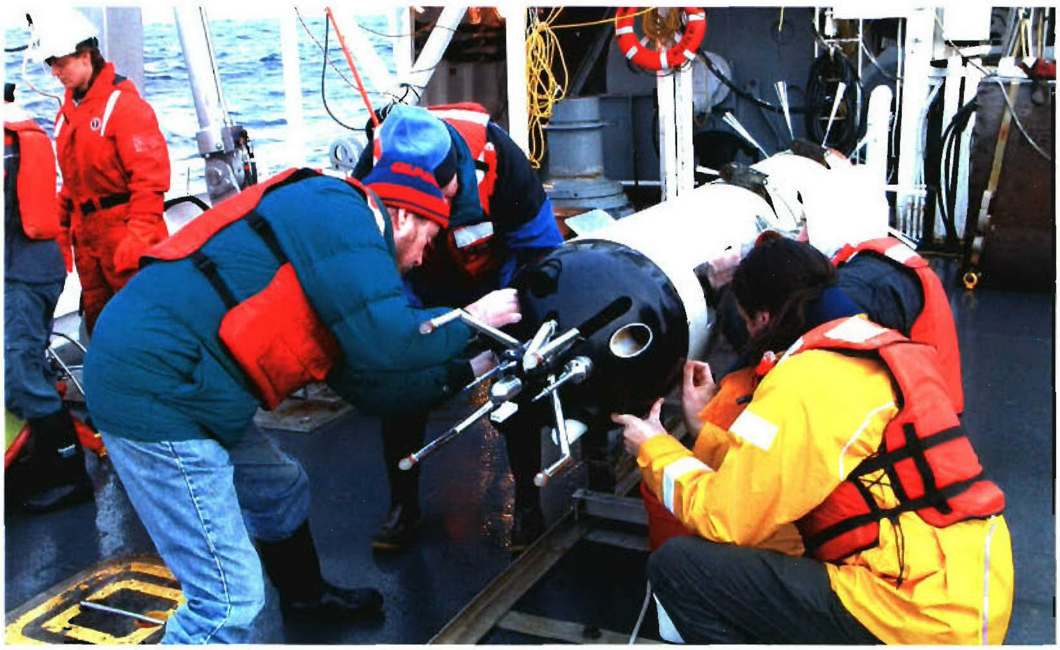
WHOI-2006-05

Woods Hole Oceanographic Institution

HRP II—The Development of a New Vehicle for Studying Deep Ocean Mixing



by Ellyn Montgomery

Woods Hole Oceanographic Institution
Woods Hole, MA 02543

February 2006

Technical Report

Funding was provided by the National Science Foundation
under Grant No. OCE-0118401 and the G. Unger Vetlesen Foundation.

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Introduction

A new deep ocean capable profiling vehicle was developed at WHOI during 2002-2003. It was modeled after the High Resolution Profiler (HRP), a robust data acquisition system for studying mixing in the deep ocean. The original HRP was built at WHOI in 1986-7, made more than 1000 profiles during more than a dozen experiments. The old system became impossible to repair, so a modern equivalent was envisioned. For lack of a more original name, the new vehicle was dubbed HRP-II.

The new instrument is a free vehicle, like its predecessor. It collects data from configured sensors while falling freely through the ocean after deployment. Not being connected to the ship by a cable removes heave, drift and other motions that would contaminate the data collected. The HRP-II uses ballast weights to descend, which are jettisoned at the end of a dive, then excess buoyancy in the body returns it to the surface where it is recovered. Normally data is only collected on the downcast, but the new profiler is capable of logging during segments of the ascent. The sensors measure temperature, conductivity and velocity on a variety of vertical scales, along with descriptors of the vehicle body's orientation in the water. Analyzed together, the data quantifies all scales of ocean mixing.

Contemporary components and hardware were employed, enhancing maintainability of the vehicle in the future. The sensor systems selected are highly accurate, and sample at precisely timed intervals. The logger program on HRP-II stores data acquired by all configured sensors simultaneously. Instrument configuration is flexible and extensible, so when newer and better sensors become available, they may be employed on the profiler. All the data is logged to memory during the dive and transferred to the disk after the weights are released. The computer disk is not used during data acquisition because the spinning could cause vibrations that may adversely affect the data. Files created during a profile are downloaded using FTP protocols to a shipboard computer after recovery.

Since the HRP-II controls its own operation, several levels of redundancy in terminating each profile were incorporated to assure recovery. The logger monitors incoming data and when any of the dive termination criteria is met, the weights are released. For additional safety, a second computer monitors the main computer's operational status, and can also release the weights. A low power condition will trigger weight release if the voltage is below a threshold. In addition to these logical methods of dive termination, several mechanical back-ups are employed. The ultimate back up system, newly implemented in this profiler, is a mud extractor. The pressure data is monitored, and if no change is detected in one minute, a 1.5 meter plastic rod is slowly pushed out of the housing, separating the profiler from the bottom.

A test cruise was planned for the conclusion of the development period in November 2003. Foul weather at that time delayed the cruise until January 2004.

The completion of the new instrument with all the enhancements, and successful operation on the test cruse was a great accomplishment. Now we look forward to using it in studies of deep ocean mixing during the years to come.

Design Objectives

The primary goal was to achieve equal or improved performance compared to the original HRP. This entailed planning for highly accurate data acquisition on a quiet vehicle capable of withstanding occasional rough handling at deployment and recovery. The intended lifespan of this vehicle is ten years or longer. In addition, the cost effectiveness of development, operation and maintenance of the new instrument was considered at all times.

With these constraints in mind, off-the-shelf components and sub-systems were selected whenever possible for this application. Suitable hardware for the main computer, and most of the sensors was identified and purchased. A CTD that fit our specifications did not exist, so a new design was developed for this application. The power control electronics and filter cards also had to be designed specifically for this instrument. The mission control and data logging software were created to fulfill the unique requirements of the new vehicle.

The requirements below remained the same for the new system. It must:

1) Operate to full ocean depth (6000 meters)
2) Be easy assemble and handle in low to moderate seas
3) Have sensors positioned to avoid flow disturbance and wake effects
4) Employ robust hardware and software and have failsafe mechanisms
5) Operate with low power consumption

The following are enhancements, new to the HRP-II:

1) Employed improved CTD, acoustic current meter (ACM), and compass sensor systems
2) Added an Electromagnetic Field (EF) sensor
3) Employed higher sampling rates for improved vertical resolution
4) Implemented more accurate timing of the A/D data acquisition
5) Added a GPS receiver for surface position logging
6) Improved altimeter control for robust near-bottom approaches
7) Modified body size, shape and stiffness to push vibration peak > 30 Hz
8) Employed external battery packs
9) Implemented a Watchdog computer to monitor logger operation
10) Employed contemporary computers of small form factor (PC104)
11) Added a bottom extractor
12) Increased data offload speed by employing current networking protocols
13) Implemented a graphical user interface (GUI) for configuration and operation
14) Added upcast data logging potential

The engineers involved in this development effort and their areas of responsibility are listed in appendix A.

Instrument Summary

The core of HRP-II is the computer, operating software, power control system and the sensors. Figure 1 diagrams the various components and displays some aspects of their connectivity. Greater detail of all aspects of the HRP-II hardware and software is detailed in the following sections.

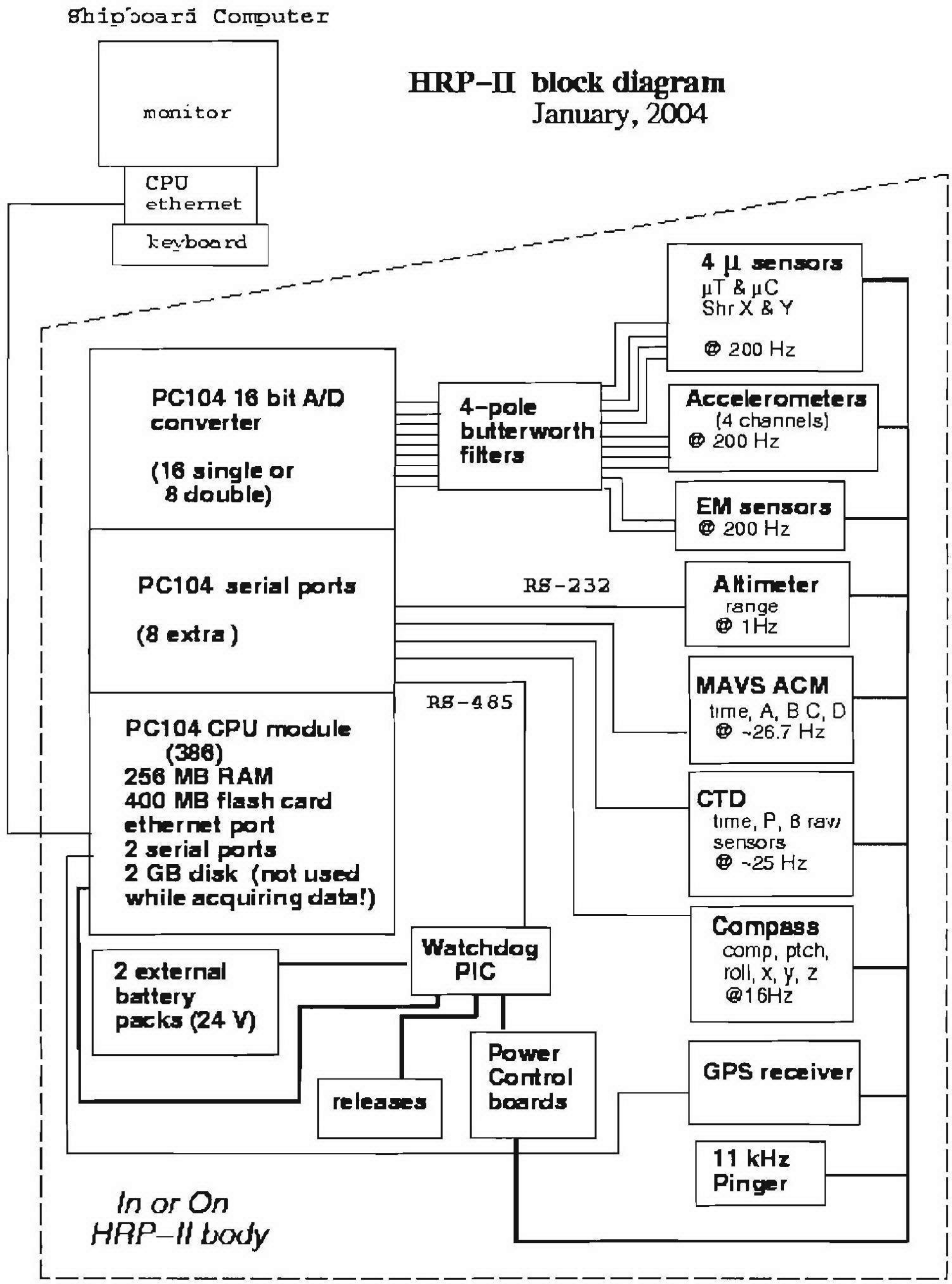


Figure 1: Components of HRP-II. The main computer is depicted in the box at the left of the figure; the sensors are in boxes to the right. Thick lines denote power connections, and thin show data pathways.

Power, Power Control Boards, Watchdog

Power to the HRP-II is supplied by two stacks of lithium "D" batteries comprised of seven cells each installed in a pressure case mounted between the skin and the main pressure housing. Each stack provides 24 volts, and is specified at 15AHr @ 175mA (~500 watt-hours for both). Lithium batteries were selected for their flat discharge profile and high current capacity. The batteries diode isolated to prevent one from charging the other.

Four power control boards are used to convert the 24 volts supplied by the batteries to levels required by the computer and sensors. The power control boards were designed for the profiler and run embedded software written in C to perform the appropriate switching and monitoring tasks. The first converts to 5 volts, which runs the computer, CTD, and other three power control boards, of which two output 12 volts, and the third 15 volts. To allow monitoring of various system status indicators, the power control board that outputs 5 volts functions as a "watchdog" that also monitors pressure, range and time, and will release the descent weights in case the logger fails to terminate the dive appropriately. A dive would also be terminated if a low voltage condition is detected, or the logger program stops running or if the pressure data from the CTD is bad. The power system is shown in figure 2.

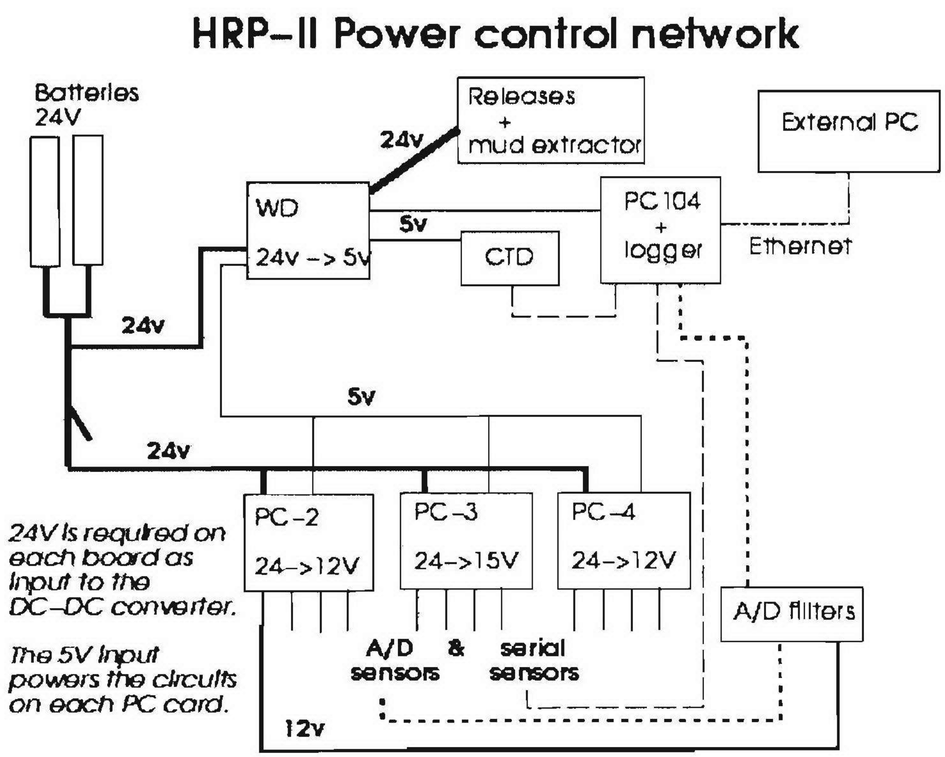


Figure 2: Diagram of the power control system employed on HRP-II

Controller:

The main computer controlling HRP-II operations is a low-power PC104 CPU with an 8-port serial card and a 16-bit A/D converter card. PC104 is a form standard widely used for small computers, so replacement parts should be available in the years to come.

Specifics of the computer are listed below:

- 200MHz 386 CPU (Lippert Coolrunner II)
- 256 MB system memory
- 400 MB of flash memory for data
- 2 GB disk (to back-up data to after a profile)
- 2 serial ports
- 1 parallel port
- 1 10/100 base-T ethernet connection
- a 16 bit A/D converter card with 16 channels (Real Time Devices DM6430HR)
- a card with 8 serial (RS232 or RS485) ports (Connect Tech Xtreme104)

The computer gets power directly from the power control board that outputs five volts, since the operation of the main computer is mission critical. A picture of the PC104 stack, filter and power control boards mounted in the chassis is shown in figure 4.

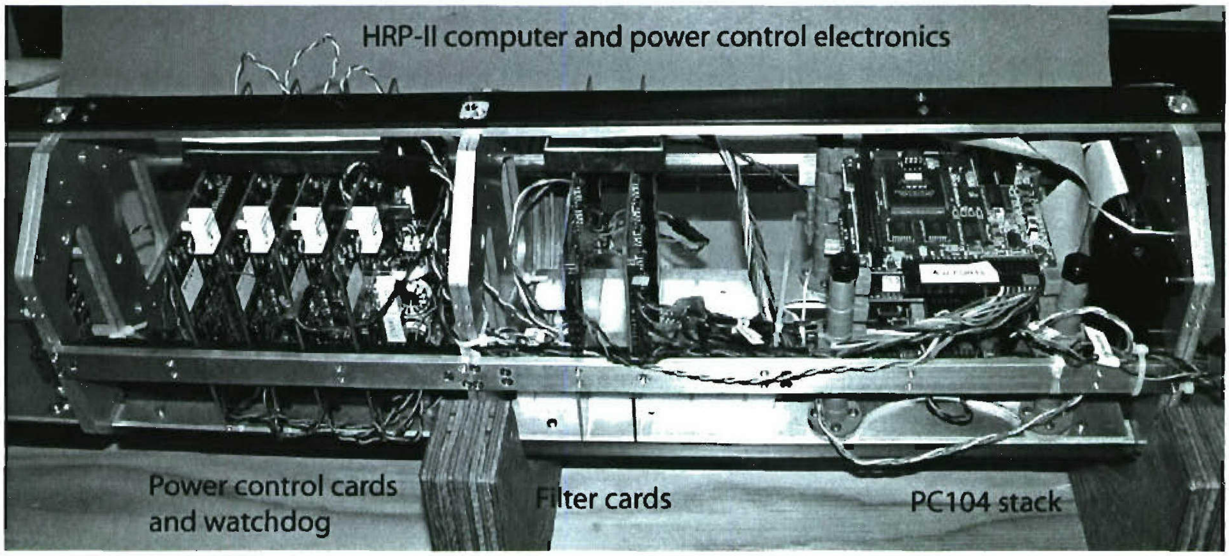


Figure 3: Photograph of the PC104 computer stack (right), A/D filters (center), and power control boards (left) used in HRP-II.

Windows 2000 was selected as the operating system, primarily because drivers for the A/D and serial port cards existed. Another plus was the National Instruments CVI software tools run under Windows 2000. The autonomous operation of the HRP-II is controlled by the logger software that was written in C for the HRP-II. The logger program (currently named hrp2.exe) was developed using CVI, which supplies functions to handle everything from the Graphical User Interface (GUI) to the serial and A/D acquisition. The software development time was decreased significantly because many subroutines already existed in the CVI libraries. The logger is the primary means of dive control, constantly monitoring the incoming data, and checking it against the dive termination criteria. It is also responsible for dive configuration, sensor control, and simultaneous acquisition and logging of data from five serial sensors and 10 A/D channels. All data is stored in memory during the downcast and written to disk at the end of the profile after the weights are released to eliminate any vibrations resulting from disk activity.

The logger was designed to allow easy reconfiguration of the sensors employed. The sensor configuration is read from a file called att_tab.asc when the logger program is invoked. It contains all the information used by the program related to sensor configuration and control (ID, port or channel, baud rate, gain, and power switch setting). Any sensor may be used or de-selected prior to each dive by clicking a button. When sensors are added or replaced, att_tab.asc must be modified to reflect the change. An example att_tab.asc is found in Appendix B.

Internal communications

The protocol used for communications between the logger program running on the main computer and the software on the Watchdog and power control boards is RS485, which allows two-way communication shared among multiple nodes. Our method is based on the logger program (controller) being the main talker, with the power control boards listening for whether the message applies to them, then acting or replying accordingly- a block diagram is presented in figure 4 below.

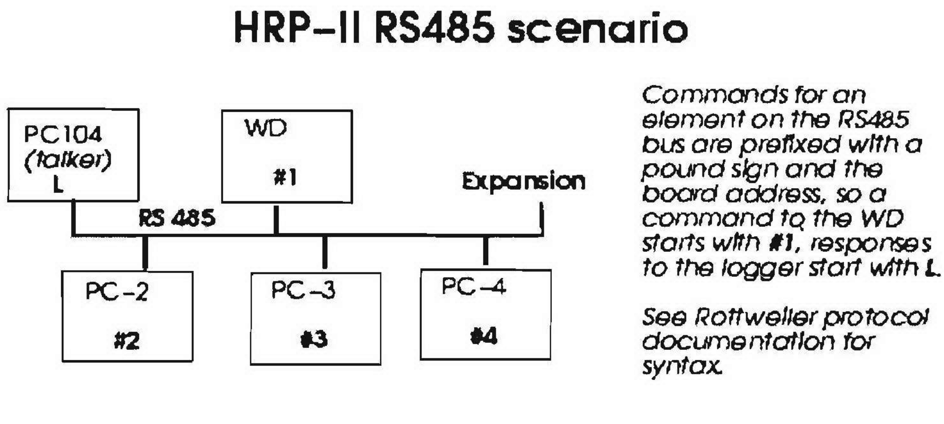


Figure 4: Schematic of the RS485 internal communications system.

A language for communication between the logger and the four power control boards was devised for this application and is documented in Appendix C. Communication between boards is necessary to accomplish tasks like 'fire the releases', 'report your current value', 'turn off power to board 3, switch 8 (the compass)'. The logger program also reports the CTD pressure and altimeter range addressed to the Watchdog every second, allowing the Watchdog to monitor the dive and the logger's functioning.

Sensors

HRP-II employs a variety of sensors to measure the smallest to the largest scales of mixing in the ocean. The underwater movement derived from the GPS data logged before and after the profile determines the largest scales, and the shear probes the smallest. Five sensors output ASCII serial data for logging, and ten sensors are connected to the A/D converter and logged as binary data. The data from each sensor is logged in a separate file, so each dive generates many files.

The synchronization of data is achieved by powering up the configured sensors well before the start of logging, so startup messages have been displayed and data is streaming from the sensors before the logger starts saving the data. The simultaneity of logging start has been verified in bench tests in the lab. Time words embedded in several of the data streams are further used to quantify drift of the clocks in many of the sensors.

The details of which sensor gets power from each board by connection to which switch number is presented in Appendix D. These tables are a wordier version of the contents of att_tab.asc (Appendix B). A list of the sensors and their manufacturers is detailed in appendix E. An example of the data format output by each sensor and file names employed is presented in Appendix F. A short description of each sensor is provided below.

CTD:

A new low noise, high precision, fast response 24-bit CTD was developed for use with the HRP-II. The thermometer was encased in a stainless enclosure to protect the fragile glass tip. The conductivity sensor was based on the internal field concept, and made for this application of ceramic with embedded fast response thermistors. The temperature and conductivity sensors are mounted on a sting that places them at the center of the sensed volume. The Druck pressure sensor is mounted directly on the lower endcap. The sample rate is 25 Hz, and a variable length serial data stream is output.

Acoustic current meter (ACM):

The electronics for a Nobska Instruments MAVS-3 was selected for this application, paired with a custom 3-axis transducer head fabricated minimize wake shedding, contribute to body stiffness, and measure both horizontal and vertical velocities in the same volume of water sampled by the other sensors. The accuracy of the MAVS velocities is 0.3 cm/sec with a 0.03 cm/sec resolution. The sample rate is 26.7 Hz, and the data is a fixed length serial data stream.

Compass:

A Precision Navigation Instruments (PNI) TCM2 three-axis magnetometer (compass) was selected for use on the HRP-II. It is mounted internally with no external expression. Both the raw x, y, z and computed pitch, roll, and compass data are output for each scan. The 16Hz sample rate is employed, and the data output is a variable length serial data stream.

Altimeter:

The electronics of a Benthos PSA 900 is mounted on the HRP-II chassis with the remote transducer head installed flush with the bottom nose cone. The 0-300 meter range in employed to maximize the possible bottom detection distance. Consequently, the accuracy of the measurement is 0.1 meter. The sensor is turned on 100 meters above the specified dive end pressure to avoid premature dive termination due to a bad range. The sample rate is 1 Hz, and the data is output as a fixed length serial data stream.

GPS:

The GPS unit selected was a Trimble Lassen SQ. A pre-amplifier was built for it and both are housed in a small pressure case mounted just below the antenna at the very top of the body. The antenna selected is made by Webb Research Company, because it is the only one made that withstands depths greater than 1000 meters. The variable length serial data messages are output as they are received.

Electromagnetic field:

The sensor developed by Sanford et al (19xx) for the MP was modified for use on the HRP-II. A specialized collar to hold the sensors flush to the skin near the middle of the instrument was designed and fabricated for the profiler. The two analog outputs are both passed through a four-pole butterworth filter before being sampled by the A/D at 200 Hz.

Accelerometers:

An orthogonal pair of Honeywell Q-flex accelerometers is mounted in a rigid housing on the inside of each endcap. The connection between the lower endcap and chassis to the upper endcap can only be made in one orientation, so the lower accelerometer pair is always aligned with the upper pair when the instrument is assembled. The four analog outputs are each passed through a four-pole butterworth filter before being sampled by the A/D at 200 Hz.

Shear probes:

The design and methods of R. Lueck were used to fabricate the shear probes in our laboratory. The sensors are mounted on custom-made stainless steel pressure cases that house signal pre-amplification electronics. The canisters are mounted on the base of the ACM sting so that the probes sample the same water as the other sensors.

The two analog outputs are passed through four-pole butterworth filters before being sampled by the A/D at 200 Hz.

Micro Temperature and Micro Conductivity:

Seabird Instruments SBE 7 and SBE 8 sensors were selected and employed without modification. The pressure cases are mounted in the space between the pressure case and the skin, with the probes mounted on the CTD sting adjacent to the CTD sensors. The two analog outputs are passed through four-pole butterworth filters before being sampled by the A/D at 200 Hz.

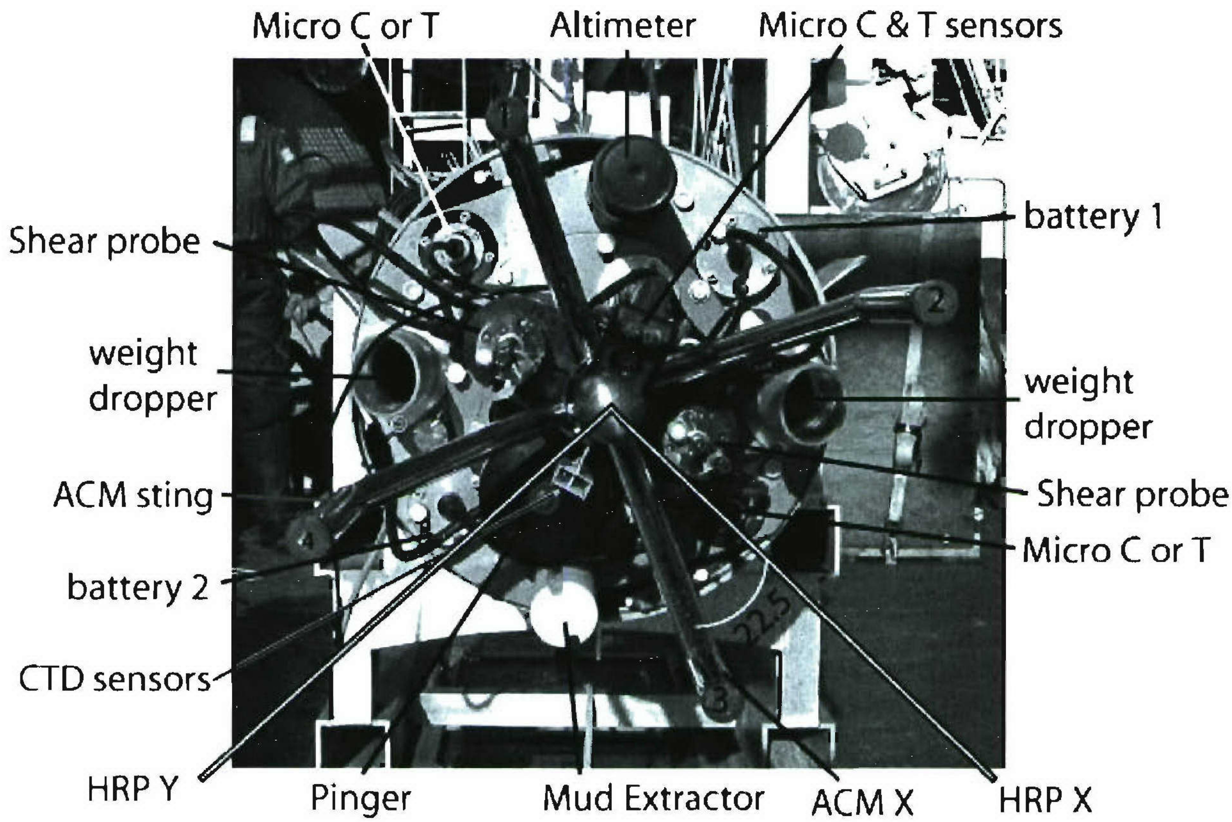
Orientation

The alignment of the sensors to each other is critical for successful analysis and intercomparison of the velocity and microstructure data. The HRP-II body was designed to rotate and oscillate along its long axis as it descends collecting data. The compass data is used to describe the rotations and later to convert velocity relative to the profiler (measured by the ACM) to earth referenced velocity. The data from the accelerometers quantifies the body motion (wobble) during a profile, which must be removed from the relative velocity and compass signals. The EF sensor data describe larger scale motions, but must also employ compass and accelerometer data to adjust it for vehicle body motion.

In the HRP-II, X is defined as "up" when the chassis is horizontal. The photo in Figure 3 was taken from above (about 30° off X), and shows the chassis in the orientation used in bench testing. Compass North is aligned to X by how the magnetometer electronics are mounted in the chassis. The accelerometers are rigidly mounted in pairs, with one of the two 90° from the other. One pair is bolted to the bottom end cap, and the other to the upper. The bolt hole positions ensure that both pairs have one sensor aligned with X. The ACM sting had to be installed with the sensors at a known offset of 22.5° to HRP-II X because of space limitations on the end cap, and to keep the transducer head from interfering with the release weights and mud extractor. The collar supporting the EF sensors should not be secured rigidly to the body due to noise issues, so it floats. However, efforts were made to ensure that it remained oriented such that EF-1 was aligned with the instrument X.

To summarize, during the test cruise, the following sensors were aligned with X: accelerometers 2 (top) and 4 (bottom), EF 1 and compass N. Figure 5.a. shows the sensor end of the HRP-II with the sensors labeled and the instrument axes added. The lack of available space is evident in the photo. The rectangular area defined by the four ACM transducers encloses the water measured. Figure 5.b.shows the orientation of the EF sensors relative to the upper endcap, again with the axes added for reference.

a)



b)

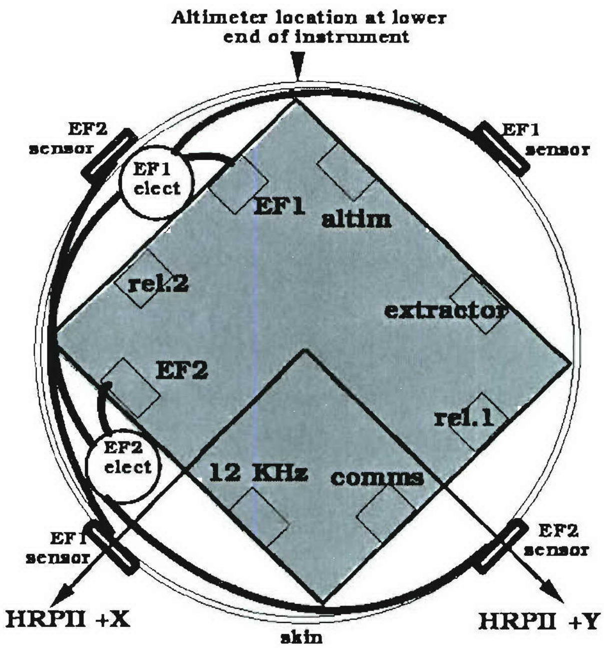


Figure 5: a) photo of the lower end of HRP-II with sensor labels, and X and Y axes added. b) schematic of the upper endcap (viewed from outside) with the EF sensor mounting and connection details noted.

Body

The body of the HRP-II is the structure that carries and protects the sensors and electronics during operation. The dimensions and materials were selected to minimize vibrations and friction, thus optimizing data quality. The body consists of five major parts: the electronics pressure case, the support and integration elements (exoskeleton, lifting bail and skin), the floatation, the battery packs and the releases, as shown in figure 6.

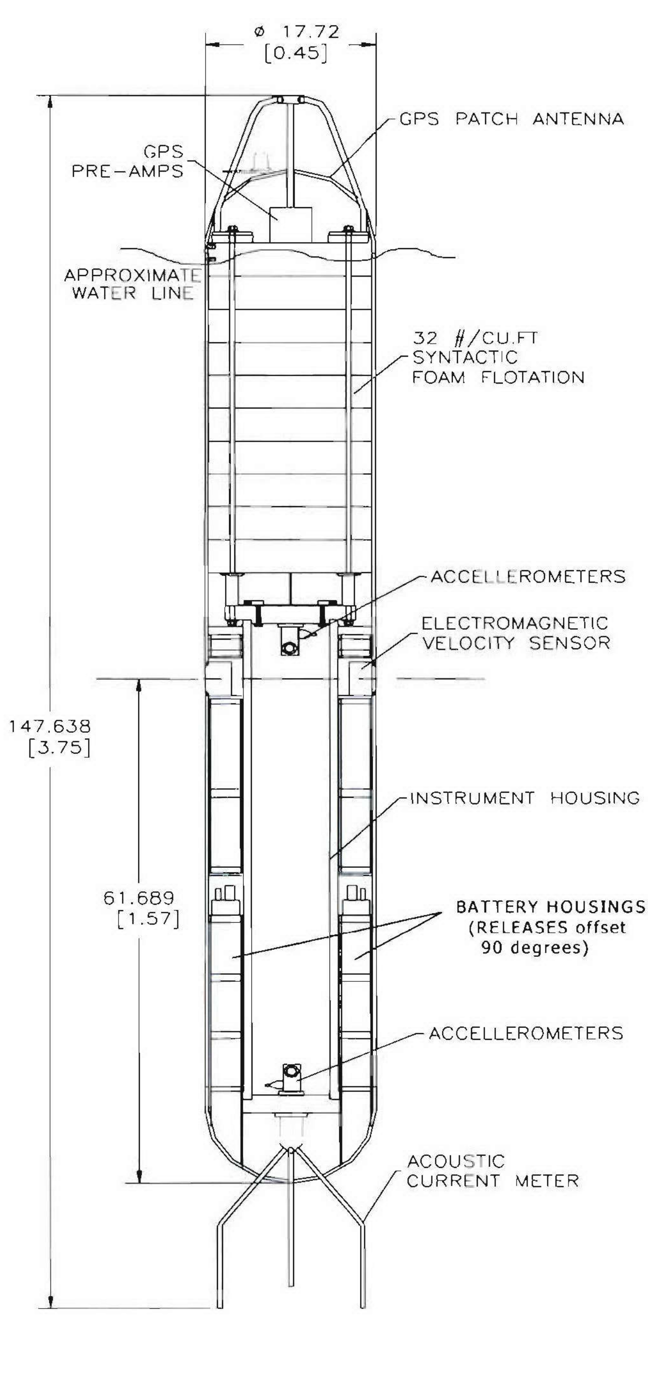


Figure 6: Schematic of the HRP-II body and structural elements.

The pressure housing holds the electronics and computers and was fabricated from eight inch internal diameter, one inch thick 7075-T6 aluminum tube, anodized to prevent corrosion. The endcaps provide the water tight seals and are made from 2.25 inch flat stock of the same aluminum. The pressure housing is secured to the floatation by a rigid titanium truss, and tie rods secure the blocks of syntactic foam to the truss. Plastic tubes and ribs form the structure that supports the skin over the pressure housing, while the floatation is shaped to support the skin directly. The skin was fabricated from two cylinders of polypropylene cut to length. By minimizing the number of seams, the frictional effects on body motion were decreased. Flexible plastic rods are assembled in rows to create drag elements (not shown in figure 6) that are attached around the circumference of the skin near the top of the vehicle. Their orientation can be varied in 30° increments and control the rate of spin along the length of the profiler.

The amount of syntactic foam attached at the top controls the rates of vehicle descent and ascent. Buoyancy tests before each experiment are required to obtain the desired nominal descent rate of 0.6m/s. The HRP-II had 45 lbs of excess buoyancy prior to the test cruise; 22 lbs of lead shot was added to the lower end of the profiler to achieve the proper buoyancy.

Two battery packs are mounted on opposite sides of the pressure housing under the skin. The power is supplied to the controller and sensors by cables connecting the lower endcap to the batteries. Each fully charged battery supplies adequate power for operations independently. Power may be switched from the batteries to the ship's power for the time the HRP-II is on deck between dives.

The solenoids that function to release the descent weights are also housed under the skin. Should the releases fail to fire, several backup mechanisms are implemented. The magnesium rods used to secure the weights in the releases come in several diameters. Each size corrodes after a certain duration, which corresponds to a depth range. Shear pins that break at pre-set pressures are also incorporated in the system. The motor that operates the mud extractor is also mounted under the skin. The plastic rod is attached to the pusher on the motor, and extends slightly beyond the nose cone when loaded.

Inside the pressure case, a chassis supports the computer, power control boards, and filters, as well as the electronics for the CTD, MAVS, compass, EF, altimeter and 12 KHz pinger. Electrical noise interference was minimized by physical separation and internal partitions separating the components. Figure 7 shows the chassis layout with some of the electronics installed.

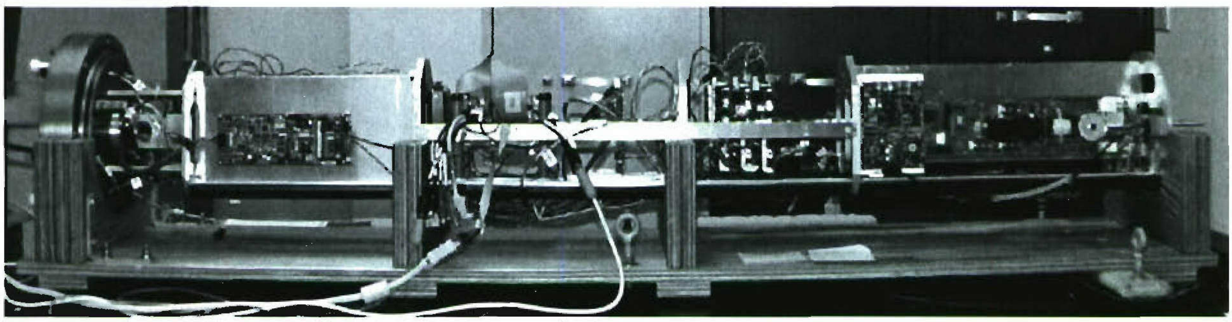


Figure 7: Picture of the lower endcap (left) and chassis that supports and isolates the electronics.

The CTD and MAVS electronics are installed nearest the sensors mounted on the bottom endcap (at left of figure 7) because minimizing the distance between the sensors and the electronics is critical obtaining for high quality measurements. The computer, A/D filter cards and power control cards occupy the middle of the chassis, and the compass, EF, altimeter and pinger electronics are near the top (right of figure7). The connection to the upper endcap during assembly is made using two blind-mate connectors that aren't visible at the right of the picture.

Operational Overview-

While the HRP-II electronics are on the bench for testing, a monitor, keyboard and mouse can be directly connected to the PC104 computer. This configuration allows exercise and testing of the logger software, sensors, and power control operation. Modifications of the logger program can be easily be made and tested in this way.

When the HRP-II is fully assembled, communications outside the pressure case are via an ethernet connection. An X-server program called VNC runs on both the HRP-II and remote computer, allowing the main computer's desktop to be displayed at the remote machine instead of a monitor. The details of initiating communication with the assembled HRP-II using VNC are presented in Appendix G.

The interface with the dive control software is through a graphical user interface (GUI) that allows the user to operate the logger by clicking buttons on the screen. No knowledge of arcane command syntax is required; configuration, testing, profile set-up and control are accomplished by clicks of a button. The main option window gives several function choices that should be executed from top to bottom. When an option on the main window is selected, a new window is created to perform specific tasks, like verify the configuration or get dive control parameters. The interface will be documented more fully in another report.

The sequence of events associated with each dive is:

- Check mechanical systems (release weights, mud extractor, lights, radio) are ready for deployment
- Check sensor configuration is correct
- Disconnect HRP-II from ship's power, and connect the batteries
- Start HRP2.exe (the logger program)
- Verify the battery voltage is adequate
- Determine water depth, then select the dive end pressure and range
- Enter dive control parameters
- Start the dive (with software)
- Verify operation while still on deck
- Disconnect communications cable and connect dummy plug
- Deploy HRP-II
- Track vehicle with echo sounder
- Find vehicle after it surfaces
- Recover HRP-II
- Reconnect communications cable
- Offload data files
- Reconnect power from the ship
- Assess data quality to see whether any sensors aren't working correctly
- Prepare mechanical systems for next dive
- Replace any sensors shown to be bad in the previous dive
- Prepare mechanical components for next dive

The handling of the HRP-II is almost exactly as it was for the original profiler. The key elements are a rolling cart on which the HRP-II is secured while on deck, and a hydraulic lifting rig that pivots to move the lift point beyond the ship's stern, so the HRP-II can be deployed and recovered without damage.

Test cruise:

During the autumn of 2003, tests of the fully assembled HRP-II were conducted at the WHOI dock. These tests indicated a number of problems that were addressed prior to going to sea. The dock tests also allowed us to verify that the sensors were aligned correctly and the channels were connected as expected. Several problems in the dive control program were also identified and fixed. The altimeter, pinger, releases, and mud extractor were also exercised during the in-water tests. Unfortunatly, there is too much metal in and around the dock to allow any but the most basic evaluation of the EF sensors. We saw changing data values written to the files, but there was no way to determine whether they were actually measuring the earth's magnetic field of that of the dock.

The HRP-II was supposed to go to sea in November 2003, but foul weather forced the postponement until January 2004. We chose to work in the area around Hudson Canyon, instead of Georges Bank due to anticipated worse weather to the east. The cruise took place on January 10–14, 2004, aboard the R/V Endeavor, cruise number 388. The HRP group shared the ship with A. Lavery and P. Wiebe's team, who worked on acoustic methods of differentiating scattering due to biology and that due to microstructure mixing. HRP-II operations took place during daylight hours, while the other work occurred overnight. The HRP team consisted of the following people: Kurt Polzin (Chief Scientist), Ellyn Montgomery, Ray Schmitt, John Toole, Ed Hobart, Bob Petitt, Fred Thwaites, Dave Wellwood, and David Steube.

During the cruise, very cold conditions were experienced. It was gratifying that none of the components froze up as HRP-II sat on deck overnight at -6°F. Once at the work site, south on New York City on the continental slope, seven profiles with the HRP-II were obtained. Software modifications made prior to dive 2 created a situation where the controller hung in a novel and unanticipated way, so no data was collected. However, the mechanical back-up release mechanisms worked, and the profiler surfaced at the expected time.

At the most basic level of functioning, the HRP-II returned to the surface for recovery every time it was deployed, though not always because both releases worked. Several of the mechanical back-ups were also tested inadvertently. The initial profiles were terminated well above the bottom for safety, but as confidence in the system was gained, near-bottom terminations were attempted.

The profiler got to a maximum pressure of 1583db on dive 5, and to within 17 meters of the bottom on the last profile, despite the altimeter not working well. The list below provides details about each dive, and figure 8 shows a map of dive positions with bathymetry contours indicating the slope of the bottom.

dive #	date m/d/y	time (GMT)	Latitude d.deg	Longitude d.deg	H2O depth	End Pres.	Dive Pmax	How Ended	Comments
1	1/11/04	15:12:19	39.547	-72.095	260	160	160	Pressure	Good dive!
2	1/11/04	19:08:00	39.102	-71.934	2250	1100	-	-	computer hung
3	1/12/04	19:26:15	39.410	-72.250	270	100	100	Pressure	verify OK again
4	1/12/04	21:07:55	39.468	-72.224	1000	800	706	Time	1 wt. off early
5	1/13/04	09:09:00	39.659	-71.436	1650	1610	1583	Shear Pin	best CTD data
6	1/13/04	11:49:25	39.670	-71.437	1590	1580	1531	Time	27 m off bottom
7	1/13/04	15:54:32	39.803	-71.383	860	835	855	Pressure	17 m off bottom

Overall, the HRP-II worked extremely well on its maiden voyage. Data from most of the sensors looked reasonable, though there were issues with the conductivity sensor on the CTD and the altimeter that must be resolved prior to further work at sea. The pinger was set to the wrong frequency, so was not "heard" by the ship, and consequently we were unable to track it during profiles. Experience using the system generated a list of handling/operations problems that need work as well. The list of things to fix created after the cruise is presented in Appendix H.

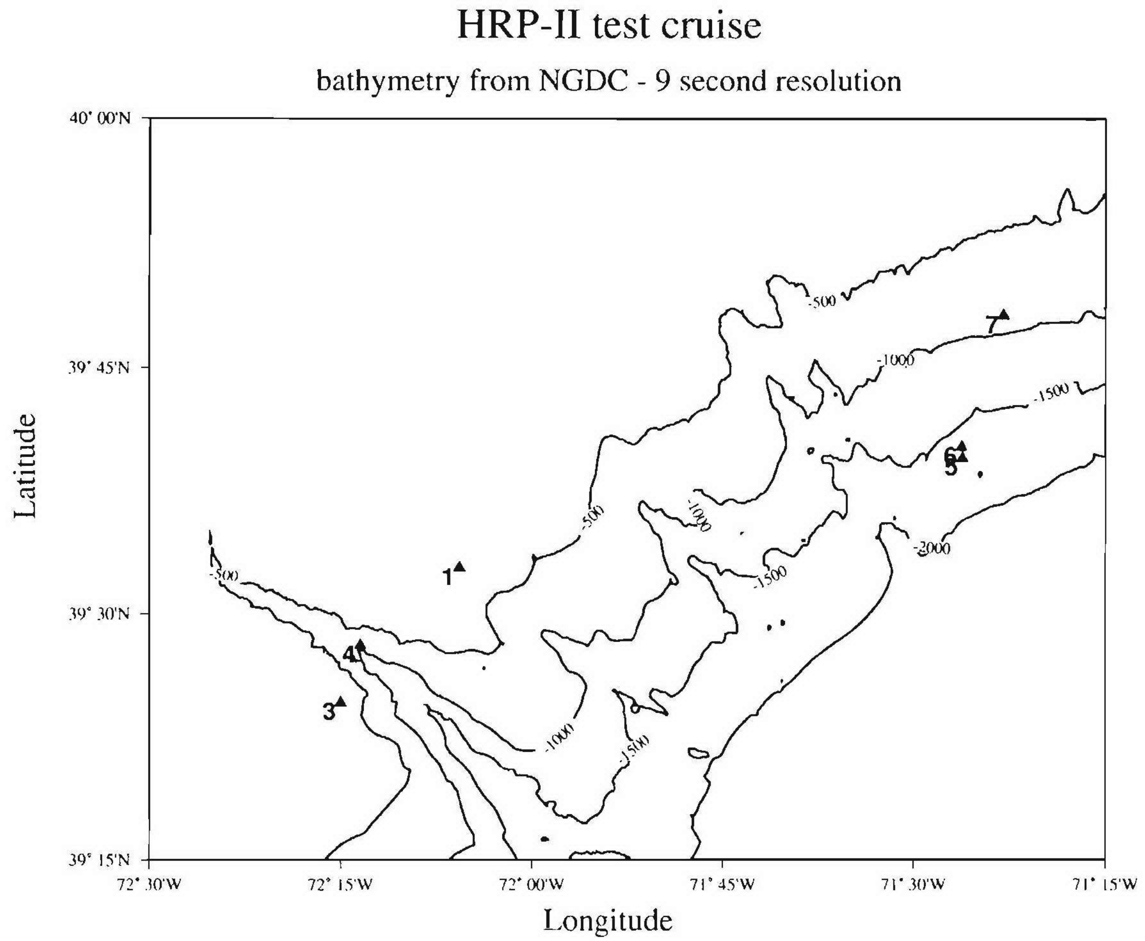


Figure 8: Map of the research area with dive positions indicated.

All in all, the cruise was a good demonstration of the operational status of HRP-II. With a relatively small amount of work, it can be made ready to use for obtaining data in actual research programs. When funding is secured, the transition from prototype to operational vehicle will be made.

Data Processing

The methods for working with the data from the HRP-II are under development. Software was developed during the operational validation and employed on the test cruise. Matlab scripts were created to unpack the data from all the sensors (each sensor outputs it's native format) and make quality control plots. This process is partially automated and is fairly speedy, so decisions on whether to change sensors can be made soon after a dive.

The programs currently needed are located in a directory on the Toshiba laptop (Oban)- c:\hrp2_code\processing. To read the CTD data, apply thermistor-derived time delays and plot, use ctd_unpk_scale_mi.m. To read MAVS data, and apply the HRP compass data to plot earth referenced velocity profiles, run hrpacmcompf.m. To evaluate compass function independently, cvt_tcm2.m allows the compass data to be plotted. For evaluating the microstructure sensors' performance prior to deploying, mic_qc.m reads the raw data, does a little filtering and generates some plots. It also calls wrt_rawm.m to combine the data from the four micro sensors and output the format used on the original HRP. Once in the old four variable binary format, the Fortran programs (deconvolve, mfft, mproc) used in the microstructure processing can be used with no modifications. These programs should be converted to Matlab, but haven't been yet. Helper functions in include rd_*.m to simply read various data formats, while plt*m and plot*m files create diagnostic plots that were used in evaluating sensor function and timing.

Earth referenced relative velocity profiles are useful, but absolute ocean velocity is the real objective. The larger scales of motion are quantified by the EF sensors and GPS. Interpreting this data and integrating it with the other smaller scale velocity measurements should not be problematic. Creating programs to resample each kind of data and output it on a common time base is also needed. Finally, an integrated method of processing the data from all the sensors and generating a standard set of plots for each dive should be implemented when the basic analysis programs work robustly. Implementation of a GUI to manage the data processing tasks is planned, but assuring the analysis software runs for each kind of data takes precedence.

Future Work

Proposals for use of the HRP-II to describe ocean mixing have been submitted, and hopefully one or more will be funded. These proposals include support for engineers to solve the problems discovered on the test cruise, so the HRP-II is expected to commence science operations with no known problems. We anticipate the HRP-II will prove itself as a robust vehicle for acquisition of data in support of research on deep-ocean mixing.

Acknowledgements-

First and foremost, thanks to the National Science Foundation for funding this instrument development effort under grant OCE-0118401. Without their support, it would have been impossible to create the new highly capable microstructure profiler, which is expected to obtain data that facilitates many studies of ocean mixing. We also thank the G. Unger Vetlesen Foundation for providing the additional funds needed to complete the instrument and participate in the delayed test cruise.

Scientific guidance for this project was provided by Kurt Polzin, Ray Schmitt and John Toole. Engineers from the Advanced Engineering Laboratory at WHOI turned the concept into reality. Ken Doherty, Terry Hammar, Ed Hobart, Bob Petitt, Robin Singer and Fred Thwaites all contributed greatly to design and development of this vehicle. Dave Wellwood made all the mechanical systems work and assured that all the spares needed were on hand.

The officers and crew of the R/V Endeavor worked diligently to make the test cruise a success. The cold weather challenged everyone, and despite the uncomfortable conditions and icing, operations went smoothly.

Appendix A: Engineering Support

Engineers involved in HRP-II development and their areas of impact.

Ken Doherty + Terry Hammar + Megan Carroll	Mechanical Gurus: responsible for body design, materials selection, battery specification, mechanical systems, EF collar, assembly. Designed and fabricated chassis.
Ed Hobart	PC/software Guru: selected, configured, formatted CPU and add-ons. Developed logger software, connectivity protocols & GUI interface.
Ellyn Montgomery	Project manager: Worked on WD/PC board software, internal communications protocol, integration, component and system testing.
Bob Petitt	Electronics Guru: responsible for CTD design and fabrication, design and assembly of WD/Power control boards and filter boards, electronics integration and testing.
Robin Singer	Developed CTD controller software.
Fred Thwaites + Craig Marquette	Designed and built custom ACM transducer sting and the transducer elements, ACM testing.

<u>Retirees:</u>

Sandy Williams	Adjusted the MAVS electronics to work with the longer path length.
Neil Brown	Designed the conductivity cell used in the CTD.

Appendix B: Att_tab.asc

This file is read by the logger program at start-up to determine the instrument configuration. The columns are: a text abbreviation of the sensor name; which board the power comes from; the switch(s) the sensor is connected to; output type (s=serial, a=A/D); the port or channel receiving the data; and if serial, the baud rate required.

snsr	brd	switch	comm	port	baud
CTD	1	78	s	7	38400
ACM	2	6	s	4	38400
GPS	1	6	s	1	9600
ALT	3	7	s	9	9600
CMP	3	8	s	3	19200
AC1	3	12	a	1	
AC2	3	12	a	2	
AC3	3	34	a	3	
AC4	3	34	a	4	
EF1	2	12	a	5	
EF2	2	12	a	6	
MC	3	56	a	7	
MT	3	56	a	8	
SX	2	34	a	9	
SY	2	34	a	10	
PNG	2	5			
RL1	1	1			
RL2	1	2			
EXT	1	3			
PC104	1	4			

** Under switch, if two characters are present, a + & - voltage needs to be supplied simultaneously, and each character represents a switch to power. The filter cards (board 2, switches 7 & 8) are not on this list because they are powered on whenever the A/D is used. This is NOT configurable so is not needed on this table.

Appendix C: RS485 language syntax

Any WD/PC board in this system can be designated as the Watchdog by setting the thumbwheel to address to '1'. The card that is the watchdog also has to have the releases, mud extractor and PC104 stack connected to it, since specialized commands are used to operate these items. This board will be responsible for monitoring operation of the vehicle and taking appropriate action in case of failure. The logger application should terminate a dive, but the watchdog will initiate termination, if any of a number of additional criteria is met.

The communication protocol between the PC/104 logging computer and a chassis of up to 16 watchdog/power-control boards is half duplex, over a bussed RS485 channel. All communication is initiated by the logger application run on the PC104 computer and all WD/PC boards listen by default. An individual board listening on the bus recognizes its unique address and responds with a formatted reply. The responding board then returns to listen mode thus freeing the channel for another query. The command protocol developed for the HRP-II is called 'Rottweiler' and is detailed below.

All commands must be preceeded by a #, have a board address, and be terminated by a <cr>. Replies from the W/PC boards are for the logger, so are preceeded by 'L'.

Rottweiler Command Summary:

Write Command	Read Command	Read Response	Function
#Alwd<cr>	#Alrd<cr>	Lwd<cr>	Write/Read LED
#1ewpDDDD<cr>	#1erp<cr>	LewpDDDD<cr>	W/R dive end pressure
#1ewrDDD<cr>	#1err<cr>	LewrDDD<cr>	W/R dive end range
#1ewtDDD<cr>	#1ert<cr>	LewtDDD<cr>	W/R dive end time
#AnwX<cr>	#AnrX<cr>	Lnwc<cr>	W turn switch(s) on ++ R display power status
#AfwX<cr>	N/A	Lfwc<cr>	Turn switch(s) off ++
#1pwDDD<cr>	#1pr<cr>	LpwDDD<cr>	W/R current pressure
#1rwDD.D<cr>	#1rr<cr>	LrwDD.D<cr>	W/R current range
#AtwDDDD<cr>	#Atr<cr>	L1twDDDD<cr>	W/R System Time
N/A	#Ahr<cr>	LhwD<cr>	Read board Humidity
N/A	#Avr<cr>	LvwD<cr>	Read board Voltage
N/A	#Acr	LcwDDD<cr>	Read board temperature
N/A	#Agr	LgwDDD<cr>	Read board GFD

#1ww<cr>	#1wr<cr>	Lww<cr>	Fire weights
#1mw<cr>	#1mr<cr>	Lmw<cr>	Operate Mud extractor
N/A	#A?r	Help message	Display help summary
#AswD<cr>	#Asr<cr>	Lsw1<cr>	W/R Dive Status
N/A	#Axr<cr>	Lxwc<cr>	*** Error Condition

Key:
# = character that indicates a command follows
A = board address(hex), if recognized by all boards. The A is replaced by "1" if the
command is specific to the WD.
X = power switch number
D = data character
d = data bit character(0 or1)
++ An 'a' replacing X (power switch number(s)) turns on/off all channels on the board
<cr> = 0Dh
*** Not yet implemented

Sample commands:
#1pw4567 : write pressure of 4567 to board 1 (the WD)
#bnw78 : turn on switches 7 & 8 simultaneously on board b
#bnr : read the status of PORTD on board b.
A response of CO indicates switches 7 & 8 are ON, 0 indicates all OFF.
#bfwa : turns off all switches on board b.
#2?r : displays a short command synopsis
#1tw0 : resets the WD seconds counter to 0
#1ww : fires the weights

Appendix D: Power Control Board assignments

Board = 1(watchdog), Address = 1, Output Voltage = +24VDC & +/-5VDC, Power Module – BWR-5/700-D48

Channel	Sensor	Voltage	Current	Power
1 (J3-1)	Weight Release 1	24V	3A	75W
2 (J3- 4)	Weight Release 2	24V	3A	75W
3 (J7- 1)	Mud Extractor	24V	100mA	
4 (J7- 4)	Data Logging PC	24V	0.42A	10W
5 (J9 – 1)	Power Boards *			
6 (J9- 4)	GPS	+5VDC	35mA	0.18W
7 (J11-1)	CTD +	+5VDC	100mA	1.2W
8 (J11-4)	CTD -	-12VDC	100mA	1.2W
Total(+/-)				

* Hardwired on, PC is turned on at startup in software.

Board = 2, Address = 2, Output Voltage = +/- 12V, Output power = 10W, Power Module – BWR-12/415-D48A

Channel	Sensor	Voltage	Current	Power
1	E Field +	+12VDC		0.75W
2	E Field -	-12VDC		0.75W
3	Shear Probes +	+12VDC		0.1W
4	Shear Probes -	-12VDC		0.1W
7	Filter Board +	+12VDC	120mA	1.5W
8	Filter Boards -	-12VDC	120mA	1.5W
Total(+/-)				3.6W/3.55W

Board = 3, Address = 3, Output Voltage = +/- 15V, Output power = 10W, Power Module – BWR-15/330-D48A

Channel	Sensor	Voltage	Current	Power
1	Accel (top) (2) +	+ 15VDC	30mA	0.5W
2	Accel (top) (2) -	- 15VDC	30mA	0.5W
3	Accel (bottom) (2) +	+15VDC	30mA	0.5W
4	Accel (bottom) (2) -	- 15VDC	30mA	0.5W
5	Micro C / Micro T +	+15VDC		0.15W
6	Micro C / Micro T -	-15VDC		0.15W
7	Altimeter	+15VDC	100mA	1.5W
8	Compass	+15VDC		.1W
Total(+/-)				2.8W/1.2W

Board = 4, Address = 4, Output Voltage = +/- 12V, Output power = 10W, Power Module – BWR-12/415-D48A

Channel	Sensor	Voltage	Current	Power
1	Pinger	+ 12VDC		0.1W
2	MAVS ACM	+12VDC		2.0W
Total(+/-)				2.1/W

Serial Channels

Channel	Sensor	Baud		
Com 1	GPS	9600		
Com 2				
Com 3	Compass	19200		
Com 4	ACM	38400		
Com 5				
Com 6				
Com 7	CTD	38400		
Com 8				
Com 9	Altimeter	2400		
Com 10	485	9600		

A/D Channels

Channel	Sensor	Gain	Bandwidth	Cal Factor
1	Accelerometer 1	1	50Hz	23.5ug/ct
2	Accelerometer 2	1	50Hz	23.5ug/ct
3	Accelerometer 3	1	50Hz	23.5ug/ct
4	Accelerometer 4	1	50Hz	23.5ug/ct
5	Micro C	1	50Hz	305uV/ct
6	Micro T	1	50Hz	305uV/ct
7	Shear 1	1	50Hz	305uV/ct
8	Shear 2	1	50Hz	305uV/ct
9	E Field 1	1	50Hz	uV/m/ct
10	E Field 2	1	50Hz	uV/m/ct

Appendix E: HRP-II Sensors employed on EN388 test cruise

sensor	sample rate	manufacturer
CTD	25Hz	(WHOI built, precision 24 bit)
pressure		Druck (model PDCR 1820-9082)
Temperature		Thermometrics (model, SP60DA202MA1) with stainless pressure housing
Conductivity		ceramic, internal-field, with embedded thermistors
Fast thermistors (2)		Thermometrics model P60DA202G
ACM	26.7Hz	Nobska MAVS-3 with custom transducer sting
EF	200Hz	Sanford et al electronics with WHOI sensor collar
Accelerometer	200Hz	Honeywell Q-flex 1400 (P/N 979-1400-011)
Magnetometer	16Hz	PNI TCM-2
Shear probes	200Hz	Lueck design, modified/fabricated at WHOI
Micro C & T	200Hz	Seabird SBE-7 & SBE-8
Altimeter	1Hz	Datasonics PSA 900
GPS	1Hz	Trimble, model Lassen SQ
Pinger		Edgetech BART special

Appendix F: HRP-II Sensor data formats

On HRP-II each sensor logs its data to a separate file, so with 15 sensors configured, you'd expect 15 files in the directory for the dive, plus the four general descriptive files made each dive. The data files are named using information found in att_tab.asc, substituted into strings as follows:

(serial data is one file per port)	dsssvvccci###.sxx / usssvvccci###.sxx
(A/D data one file per channel)	dsssvvccci###.axx / usssvvccci###.axx

where : d = downcast, u = upcast
sss = sensor name string (acm, ctd, gps)
vv = 2 character vessel ID (en, oc), ccc = cruise number (388)
i= 1 character cruise ID letter (d), ### is the profile number (zero padded, 005)
s = serial port, a = A/D channel, xx = the numeric identifier corresponding to data address
(.s07 = data from serial port 7, .a10 = data from A/D channel 10)

There is no header in any of the data files - one header file **hdren388d###.txt** applies to all the data for the profile. A sample (**hdren388d005.txt**) is below.

```
SHIP: Endeavor
CRUISE NO: 388
CRUISE ID: en388td
DIVE NO: 5
EXPERIMENT: test cruise
LATITUDE: 39 40.60
LONGITUDE: 71 25.00
DECLINATION: 14.6
WATER DEPTH(m): 1650.000000

CTD Deck Pressure(db): 0.554
CTD Deck String:
0.575    7916533  186300994   5510391  204383323  201485096  270374140  4127   24402861
Deck Battery Voltage: 25.65
GPS ON/OFF PRES(db): 10
UP END PRES(db): 10
DOWN END PRES(db): 1610
END RANGE(m): 50.000000
DOWN MINUTES: 85
TOTAL MINUTES: 130
INITIAL DELAY: 3
OPERATOR: etm

PROFILE START Time: 4:03:56
Start Logging Time 4:7:11
Down Ending Time 5:30:53
Ending Pressure 0
Ending Range 0.700000
PROFILE ENDED DUE TO: User
```

The sensor configuration used on each dive is stored in **divcfgenn388d###.txt**, providing a record of what was turned on and which settings were used:

```
dive no 5, down minutes 85, end press 1610, end range 50.0
serial ports
port state id baud board switch
```

1 ON GPS 9600 1 6
3 ON CMP 19200 3 8
4 ON ACM 38400 4 2
7 ON CTD 38400 1 78
9 ON ALT 2400 3 7
a-to-d ports
port state id gain board switch
1 ON AC1 1 3 12
2 ON AC2 1 3 12
3 ON AC3 1 3 34
4 ON AC4 1 3 34
5 ON MC 1 3 56 s/n 070113 tip 1
6 ON MT 1 3 56 s/n 080114 tip 1
7 ON SX 1 2 34 can 25 prb 68 prb_gain 0.0
8 ON SY 1 2 34 can 21 prb 78 prb_gain 0.0
9 ON EF1 1 2 12
10 ON EF2 1 2 12
power info
PNG, 4, 1
RL1, 1, 1
RL2, 1, 2
EXT, 1, 3
PC104, 1, 4

In addition to the header and configuration files, there are two additional files related to the operational status of the instrument. All the RS485 traffic is stored in **drs485en388d###.txt**, and the internal sensors (board temperature, humidity, voltage, ground status) are in **dvthgen388d###.txt**.

Five sensor systems store their data as ASCII data (described below), and the 10 sensors acquired by the A/D are binary files of type = float. The samples are stored sequentially in the order received. All the files start simultaneously, so the sampling rate or internal clocks must be used to synchronize the various sources of data.

ASCII formats
==

CTD data - named **dctden388d###.s07** - sample rate : 20Hz

the contents of the data files, by column, is : nominal_processed_pressure, raw_pressure, raw_temperature, raw_conductivity, ??, fast_T_1, fast_T_2, ??,??, internal_time (picoseconds)- this is not relative to anything else, just lets one evaluate intra-sample drift.

0.492	7913573	6011964	5508329	203400340	198597452	181393661	2363	191606261
0.467	7912760	6011050	5508418	203384197	198576755	181403347	2363	191646269
0.518	7914411	6010068	5508628	203346280	198585155	181412646	2363	191686247
0.679	7919636	270652062	5508952	203283710	198626553	181429127	4411	191726256
0.633	7918138	270656725	5508488	203203141	198657206	181441419	4411	191766265
0.611	7917431	270657567	5508647	203126700	198663706	181448731	4411	191806273
0.613	7917485	535281924	5508738	203027208	198649603	181453162	8507	191846252
0.609	7917355	535283908	5509100	202936812	198635555	181462702	8507	191886259
0.562	7915851	535284591	5508956	202849177	198612191	181471394	8507	191926269
0.551	7915497	181613742	5508792	202770529	198578196	181485008	319	191966276
0.587	7916660	181619366	5509017	202688571	198539885	181492468	319	192006255
0.574	7916220	181624896	5509459	202585170	198495704	181498668	319	192046263

A conversion must be applied to this data to output P, T, C- the program to so this is under development.

MAVS data - named dacmen388d###.s04 - sample rate : 26.7Hz

The columns contain time (milisecs) and raw travel times along the acoustic paths A-B B-C C-D D-A. The time is not relative to anything external, is used to evaluate intra-sample drift.

```
.168 E807 F30C EBD2 F120
.206 E7A7 F304 EC4A F160
.245 E7FF F334 EBFA F188
.283 E7B7 F2EC EC12 F148
.322 E7BF F2C4 EC3A F180
.360 E7EF F334 EC32 F120
.398 E78F F2C4 EC32 F108
.437 E7EF F2EC EC5A F210
.475 E7A7 F2BC EC3A F138
.513 E7F7 F30C EBFA F168
```

Compass data - named dcmpen388d###.s03 - sample rate : 16Hz

The compass 0 (N) is aligned with HRP. The data is compass heading, pitch, roll, and then the raw x, y, and z accellerations, so you can compute your own headings. The * indicates the beginning of the checksum, and if there's an E for error, it follows the last data and preceeds the *. Use cvt_tcm2.m to read this data.

```
$C47.8P-4.7R-12.5X41.67Y-51.12Z39.65*33
$C47.6P-4.4R-12.1X41.65Y-50.85Z39.89*35
$C47.7P-4.3R-11.7X41.59Y-50.63Z40.00*3E
$C47.7P-4.0R-11.3X41.49Y-50.39Z40.33*37
$C47.4P-3.9R-10.9X41.51Y-50.15Z40.63*33
$C47.5P-3.6R-10.5X41.39Y-49.91Z40.74*3D
$C47.5P-3.4R-10.1X41.25Y-49.69Z41.09*3A
$C47.3P-3.2R-9.6X41.26Y-49.43Z41.37*03
$C47.3P-2.9R-9.2X41.17Y-49.19Z41.60*02
$C47.5P-2.7R-8.7X40.98Y-48.96Z41.91*00
```

Altimeter named dalten388d###.s09 - sampled at 1Hz

The data is temperature (°C) and range from the bottom (meters). This sample is garbage- when working correctly, it should show a monotonic decrease in range of about .7m/scan with fairly constant temperature.

```
T21.6 R228.0
T21.6 R219.8
T21.4 R204.9
T21.6 R210.2
T21.4 R225.8
```

GPS named dgpsen388d###.s01

This data is only sampled prior to deployment and prior to recovery. It does not have to be synchronized with any of the other data. This shows a segment with no satellite lock, and then with some good data showing that it was at 39.39.4286N, 71.26.1973W (the GGA string is the important one here)

```
$GPGGA,,,,,,0,05,,,,,,,*63
$GPVTG,,,,,,,,,N*30
$GPGGA,,,,,,0,05,,,,,,,*63
```

```
$GPVTG,,,,,,,,,N*30
$GPGGA,101310.00,3939.4286,N,07126.1973,W,1,05,1.28,-00008,M,-034,M,,*7B
$GPVTG,136.0,T,149.9,M,002.6,N,004.9,K,A*2B
$GPGGA,101311.00,3939.4275,N,07126.1984,W,1,05,1.28,-00007,M,-034,M,,*71
$GPVTG,147.2,T,161.1,M,003.4,N,006.2,K,A*27
$GPGGA,101312.00,3939.4270,N,07126.1988,W,1,05,1.28,-00007,M,-034,M,,*7B
$GPVTG,223.6,T,237.5,M,001.1,N,002.0,K,A*27
$GPGGA,101313.00,3939.4270,N,07126.1992,W,1,05,1.28,-00006,M,-034,M,,*70
$GPVTG,326.0,T,339.9,M,000.8,N,001.5,K,A*28
```

The get_imet.prl program should be adaptable to parse this data, but we got so few GPS records on the test cruise that we didn't make the necessary changes yet.

Binary data

==

A/D channels are sampled at 200 Hz and passed through a butterworth filter before storage. Each contains a sequential stream of words. All these files should be the same length for a profile, given they're logged for the same duration. rd_adbin.m and rd_adbin_gui.m allow these files to be read into Matlab for quality control plotting. To process using the original micro programs, convert the four micro files (sx, xy, mc, mt) into the old format using wrt_rawm.m. The file names associated with the sensors that output binary data are:

```
dac1en388d###.a01 four accelerometers
dac2en388d###.a02
dac3en388d###.a03
dac4en388d###.a04
dmcen388d###.a05  Micro T & C
dmten388d###.a06
dsxen388d###.a07  Shear x & y
dsyen388d###.a08
def1en388d###.a09 EF 1 & 2
def2en388d###.a10
```

Appendix G: Communications with HRP-II

External : via the Ethernet connection
Ethernet is the only method of communicating that works when the electronics are in the pressure case! You can use Ethernet to talk to HRP-II when the electronics are out, but connecting a keyboard, mouse and monitor is usually worth it due to faster response times.

1) Connect the 5 pin -> Ethernet plug to the HRP. The Ethernet end should be connected to a netgear box or the network, with the user's computer connected to either.
2) Given the HRP-II computer is ON, establish communications by either:
    a) using a java enabled browser, set the link to http://128.128.97.103:5800
    b) using VNC software, connect to 128.128.97.103 (password=hrp)
    (on HRP-II the VNC server should be enabled- if it got inadvertently turned off it must be reset before using VNC!)

   The user's computer MUST use the same subnet address, and while at WHOI, 128.128.97.98 is a good setting for the other computer.
   ++ If you need to log on, do so as Administrator, password=hrp. ++

Now you should be able to view the screen of the HRP-II computer's desktop in a window on your computer. The mouse works, but response will be SLOW, due to having to maintain the windows information and translate all the clicks back and forth.

To prepare for a dive or run tests, start the hrp2.exe program. It should bring up a GUI interface that provides the operator with various functions associated with configuration, testing and operations.

Use HRP2.exe to view or log data. (there should be a shortcut to hrp2 on the desktop)

c) Data logged by the viewer will be under \data\200X..... where the directory corresponds to the date created, and the file names are based on the time created. The suffix indicates the sensor data source.
d) Data logged while running a dive is stored in \data\experiment\dive*.*.

Before FTPing files off the disk in HRP-II, you have to enable the server. Serv-U is the program, and there should be a U on the bottom taskbar, with a red line through it. Right mousing it allows it to be turned on or off. Only leave it on when transferring data.

Use WS-FTP95, or procomm to grab the files desired. The server account username is hrp, password is moejoe.

Via direct connection to PC104 stack
When the electronics are out of the pressure case, and component testing occurs, connecting a monitor, keyboard and mouse to the PC104 stack is the optimal way to connect to the HRP-II

To communicate directly between the PC104 stack and the WD/ PC cards (RS485) use Hyperterm (under programs, accessories, communications). There should be a shortcut to Hyperterm on the desktop. The settings should be set up so you can just open wd.ht, but if you need to set it up, here's what you need:

e) COM10
f) 9600 baud, 8 data bits, no parity, 1 stop, no flow control
g) under the settings tab, select : terminal keys, Ctl+H, AnsiW, VT100, 500, then under the ASCII setup button (receiving), choose "append ff to line end".

Procomm will do RS485, but it will not do COM10, so you MUST use Hyperterm!!!!!

You can also use Hyperterm and Procomm together to view data and test sensor function, if you choose-

h) In hyperterm, issue a command like #1nw78 to turn on the CTD
i) In Procomm view the CTD output on comm7 at 38400 baud.
j) In hyperterm turn off the CTD with #1fw78.

For this method to be effective you must know which ports each sensor is connected to!

For the test cruise, we used the following:

CTD	1	78	s	7	38400
ACM	2	6	s	4	38400
GPS	1	6	s	1	9600
ALT	3	7	s	9	9600
CMP	3	8	s	3	19200
WD	1	1	s	10	9600

The output of the A/D converter cannot be observed in this way.

A RS232/RS485 converter (B&B Electronics) must be employed to communicate from the laptop's DB9 serial port to the WD. With this connector in place, the laptop can monitor or log the traffic on the RS485, as the Logger program issues commands, and the other cards respond. Individual cards can also be exercised by sending commands from the laptop when the converter cable is connected.

Appendix H: Items to be fixed on HRP-II

Logger Software

- verify interplay and consistent behavior of the watchdog and main controller (e.g., identical end of logging behavior regardless of how the dive is terminated - RTERM still has problems)
- pass dive parameters to watchdog asap and initiate watchdog ops before logging is started.
- initiate GPS logging on initial startup, (before the other sensors start, so it can aquire data before sinking)
- increase time between sequential fires of releases

Sensors

- improve the altimeter's ability to find bottom or find another altimeter to use
- check output of 12 kHz pinger, improve shipboard signal reception (we didn't hear the pinger because it was set to output a different frequency internally- that's fixed, but it should still be checked)
- increase ping rate on up-profile to better facilitate tracking
- test GPS reception as a function of antenna angle
- improve mechanical strength of the CTD's conductivity cell and internal thermistors
- identify and fix the source of partial CTD data records
- validate the new CTD performance with detailed lab calibration and piggyback profiles with standard shipboard CTD system

Body

- consider moving 12 kHz pinger to top of body to improve signal reception
- revise GPS antenna mounting so that it is better protected
- make sure the battery pressure cases are clear of obstructions during removal (on test cruise they were blocked by the zinc anode and the 12 kHz mounting bracket)
- combine on-deck comms and shore-power cable to simplify swapping to lab-power and thus save internal battery power during time on deck
- reduce variety of bolt types and sizes to make at-sea maintenance simpler
- brighter paint job
- improve weight release doors (perhaps develop an overlapping door faired to the skin and hinged) to simplify deck operations
- add a pressure-case purge system to insure dry atmosphere inside the instrument after openings
- acquire a blank end cap to seal pressure vessel while electronics are being serviced
- one long (100+') ethernet cable with no couplers (they leak!)

Electronics

- add second capacitor to weight release solenoid circuit so that there
- is one cap per solenoid
- increase gain in the accelerometer channels and calibrate output from all 4

Batteries & Power Control

- explore ways to test remaining battery capacity (e.g. voltage measurement under various loads)
- add an "electric meter" on the battery packs that will accumulate output amps to better guide battery replacement decisions.
- explore use of rechargable batteries (cost, capacity,...)
- run HRP-II on bench under full load and measure current used. Give info to Steve L. so he can estimate how much to derate the BCX85 battery pack.

Data processing

- quantify microstructure noise levels based on test cruise data
- assess quality of the EM current meter data; derive test-cruise velocity profiles
- determine if the fast spin rate (one rev per ~15 m) is necessary for the EM current meter, and/or if errors contaminate derived velocity at rev period

- develop point-mass ocean velocity algorithm for HRP-II; apply and compare results to above (Former will require detailed estimates of body dimensions and mass)
- refine compass calibration; work out how to estimate direction based on raw magnetometer and tilt data
- devise a faster way to read the raw data files into the analysis computers (perhaps for now, just manually edit the serial data files to insure first and last data records are complete strings)
- create a data structure for both fine and micro files with links to (updated) reduction/analysis routines and final products

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16. Abstract (Limit: 200 words)

The High Resolution Profiler II (HRP-II), a unique, autonomous untethered, deep-ocean capable, profiling vehicle was designed and developed at WHOI during 2002-2003. During a vertical profile, it measures and records temperature, conductivity, pressure, horizontal and vertical components of velocity and turbulent-scale temperature and velocity gradient data. Great care was taken to minimize vibrations that would contaminate data from the microstructure sensors; the vehicle's movement is driven by graity, the body materials and shape were optimized for stiffness and no computer disk activity is allowed while profiling. All sensors are positioned to measure the same volume of water, and allow undisturbed flow to reach each one. The HRP-II was tested over the continental slope in January 2004. All aspects of vehicle function were successfully tested during seven profiles, the deepest of wwhich was to 1583m. On one dive to 835m, termination was achieved at 17m above the bottom, close to the design specification. Several sensor and controller issues were identified that need to be resolved, but overall the vehicle performance on the test cruise was exceptional. The vehicle design specification, mechanical and electrical systems, sensors, controller, communications protocols, and testing of the HRP-II are documented in this report.

17. Document Analysis a. Descriptors

turbulence microstructure
absolute ocean velocity
low noise free vehicle

b. Identifiers/Open-Ended Terms

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